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Policies and legislation driving Taiwan's development of renewable energy

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ABSTRACT

Under the current wave of international responses to the growing threat of climate change, Taiwan cannot afford to step back from its goal of advancing its renewable energy, strengthening its energy self sufficiency and energy security. This paper will first analyze the high level dependency structure of Taiwan's energy demands; then we will explore Taiwan current situation in terms of renewable energy development; furthermore from an overview of the course of changes and development in Taiwan's energy policy, highlight the commitment to and aims of Taiwan's Renewable Energy Development, made by the government at the Annual National Energy Conference. Fourth, we shall analyse technological R&D, incentives, taxes, market reforms and other related policy tools. Fifth, in light of public announcements and budgets set in recent years for Taiwan's renewable energy research plan, highlight main strategies being given impetus by the government. Sixth, the author will discuss the implications of recent significant legal reforms to the development of renewable energy in Taiwan and from the correlating aspects of industrial structures and energy consumption, take the first steps in emphasizing the urgent need for adjustments to be made to Taiwan's industrial structure. Finally, this paper will conclude by examining current policies, legislation and strategies which are in place to promote this area in Taiwan and discuss the potential competitiveness and future scenarios which the development of Renewable Energy could mean for Taiwan.

Contents

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1. Introduction

At the end of 2009 the United Nations Framework Convention on Climate Change (UNFCCC), will be meeting for the third round of talks in Copenhagen, Denmark, world governments will be challenged with concepts of 'low carbon society' and 'low carbon economy' as well as numerous calls to strengthen research and industrial development of renewable energy. For Taiwan, a high energy consumer and fossil fuel import dependent country, the question of how to strengthen renewable energy in terms of scientific research and industrial development should not only be concerned with implementation of the demand reduction aspect of international treaties on reduction of greenhouse emission but also touches on the more overarching need for greater energy self sustainability and energy security.

As a newly emerging industrial nation, Taiwan has in its recent past tended towards an industrial structure with a greater bias towards manufacture industry, as a result, energy consumption and greenhouse gas emissions is relatively high. From the end of 2008 Taiwan's overall total greenhouse gas emissions made up 1% of the world's total emissions and ranked 22nd globally; while Taiwan's CO_2 emission per person also ranks high at 24th globally. With its relatively low energy efficiency and mainly export led industries, in the face of the challenge set by international climate change treaties, Taiwan prospects are grim. In recent years the Taiwan government has actively made revisions to its 'Electricity Act', 'Petroleum Administration Law' and 'Energy Management Law'. And 'Green Gas Reduction Act', 'Sustainable Energy Basic Law', 'Energy Tax Act' are current intensively promoting. In June 2009 the 'Renewable Energy Development Law' was passed with a variety of policy tools to actively promote greater capacity in scientific research and industrial and market competiveness. Therefore this paper will analyze and examine the importance and problems of developing renewable energy in Taiwan from both political and legal aspects and propose a strategy to give greater impetus to actively pursuing sustainable development.

2. Taiwan energy: supply and demand

Since 1993 Taiwan's energy consumption has been on the rise but in 2008 as a result of the global energy crisis it gradually slowed a little. According to Taiwan's Bureau of Energy at the Ministry of Economic Affairs' most recent statistics (refer to Fig. 1), Taiwan's total domestic energy consumption has already reached 1176861 $\times$ 10^3 KLOE, while its total energy supply reached 142475 $\times$ 10^3 KLOE. However since Taiwan does not possess a wealth of natural resources, almost all of Taiwan's fuel energy is dependent on imports. The statistics (Fig. 2) show that in 2008, of Taiwan's overall supply of energy, only 247 $\times$ 10^3 KLOE was self-produced energy, or 0.7%. While imported energy reached 141527 $\times$ 10^3 KLOE or 99.3% of total supply; this structure was very similar to the statistics for 2007. That is to say that from an energy security perspective, Taiwan is too dependent on imports for its energy; therefore, developing self sustainable energy, in particular renewable or new energy is of vital importance.

While from an analysis of energy supply structures, in terms of total overall supply, Taiwan's current energy use is still mainly dependent on imported traditional fossil energy (Fig. 3); in 2008 fossil fuels made up 91.29% of all energy used. Out of this crude oil & petrol products made up 49.5% and coal & coal products another 32.4%. The concentrated dependency on these two energy fuels, on the one hand clearly shows the high level security problem which Taiwan's current energy supply poses and the need to implement diversification in energy supplies and self sustainable development; on the other, it also shows the relatively high CO_2 emission rate caused by energy consumption, which in itself is a violation against the emerging international trend towards environmental protection.

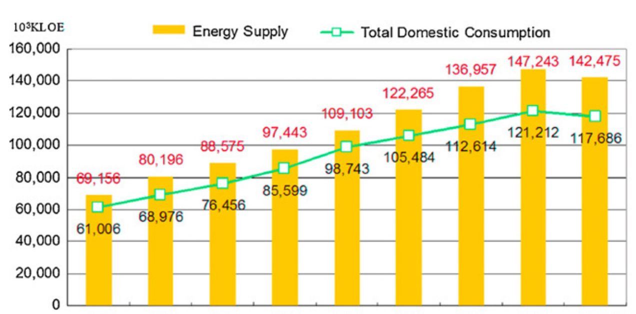


Fig. 1. Energy supply and total domestic consumption.*Data source*: MEA [1].

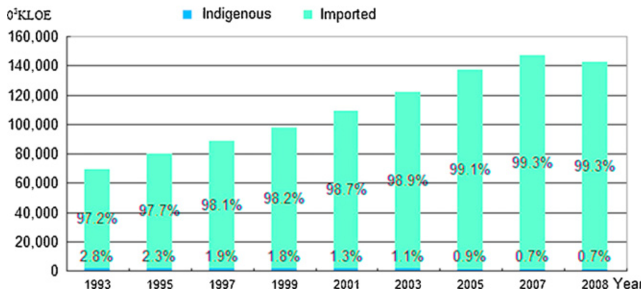
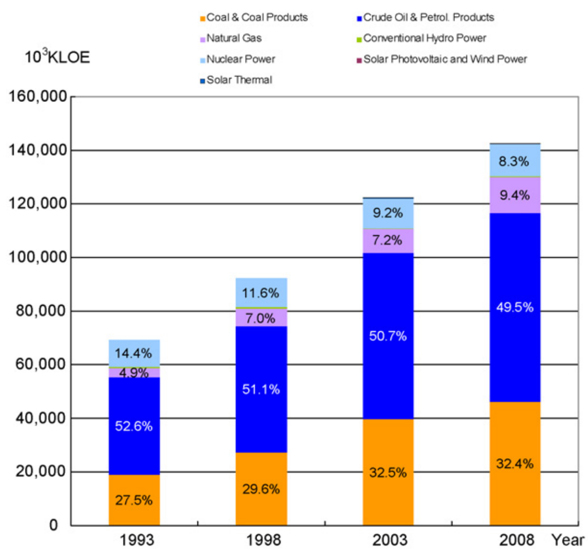


Fig. 2. Energy supply (indigenous & imported).*Data source*: MEA [1].



Year	1993		1998		2003		2008	
Coal & Coal Products	19,051	27.55%	27,266	29.57%	39,731	32.50%	46,187	32.42%
Crude Oil & Petrol. Products	36,350	52.56%	47,120	51.11%	62,039	50.74%	70,467	49.46%
Natural Gas	3,374	4.88%	6,488	7.04%	8,852	7.24%	13,420	9.42%
Conventional Hydro Power	393	0.57%	593	0.64%	290	0.24%	412	0.29%
Nuclear Power	9,949	14.39%	10,664	11.57%	11,262	9.21%	11,823	8.30%
Solar Photovoltaic and Wind Power	1	0.00%	0	0.00%	2	0.00%	57	0.04%
Solar Thermal	39	0.06%	70	0.08%	88	0.07%	110	0.08%
total	69,156	100%	92,201	100%	122,265	100%	142,475	100%

Fig. 3. 1993–2008 Taiwan's structure of energy supply (by energy form).*Data source*: MEA [1]; author's construct.



Year	1993		1998		2003		2008	
Thermal	13434.7	63.49%	20081.5	67.73%	30442.0	75.90%	36440.0	78.57%
Hydro Power	2576.0	12.17%	4422.0	14.92%	4510.8	11.25%	4539.9	9.79%
Nuclear Power	5144.0	24.31%	5144.0	17.35%	5144.0	12.83%	5144.0	11.09%
Solar	0.0	0.00%	0.0	0.00%	0.5	0.00%	5.6	0.01%
Geothermal	3.3	0.02%	-	0.00%	2.4	0.01%	131.8	0.28%
Wind	1.3	0.01%	0.0	0.00%	6.1	0.02%	120.3	0.26%
Total	21,159	100%	29,647	100%	40,106	100%	46,382	100%

Fig. 4. Installed capacity power.*Data source*: MEA [1].

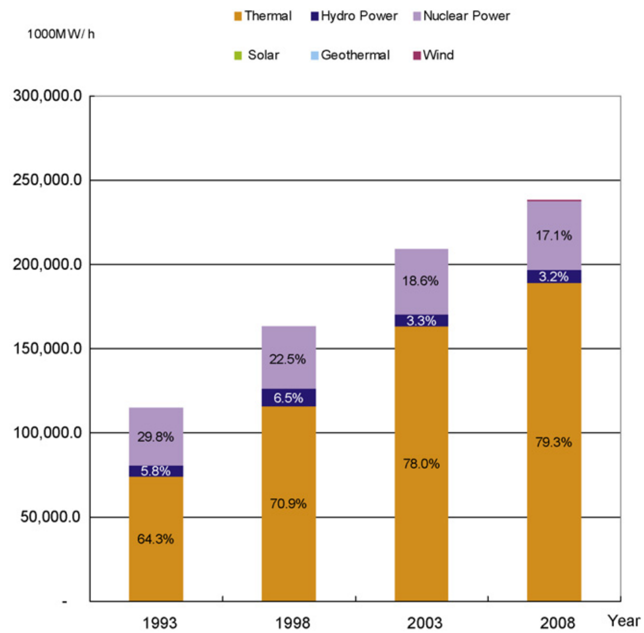
From the structure of generated installation capacity (Fig. 4), similarly to 2003, in 2008 thermal energy made up 78.6%, nuclear power 11.1%, and hydraulic power 9.8%. In the past three years the installed capacity of renewable power has rapidly increased, in 2008 the combined power supply capacity from Taiwan's renewable electricity generator systems, including wind power, geothermal power and solar power had reached 257.7 MW[1] and made up 0.55% of overall installed capacity; of this, wind power accounted for 120.3 MW or 0.26%, Geothermal power accounted for 131.8 MW or 0.28% while solar power reached 5.6 MW or 0.01%.

From the proportional structure of overall power generated (Fig. 5) we can see that the power generation structure in Taiwan is almost unchanged from that in 2003. In 2008 Thermal power accounted for 79.3%, nuclear power 17.1% and hydraulic power 3.2%. Of this, the installed capacity of renewable energy again has rapidly increased with wind, geothermal and photovoltaic power capacity reaching a combined total of 593.5 Gwh[2] in 2008 or 0.25% of Taiwan's overall generated power; wind power accounted for 589.3 Gwh of this figure, or 99% of all renewable energy power generated while photovoltaic power accounted for only 4.2 Gwh, or less than 1% of all renewable power generated, leaving a lot of room for growth and improvement.

From the structural analysis of energy above, it is clear that Taiwan's energy supply is highly vulnerable. The power installation structure and proportional structure of power generated both point to the over-dependency of Taiwan's energy supplies on fossil energy [2], which is reflected in the problems facing other countries such as Switzerland, Japan and South Korea. In conclusion, in order to strengthen energy security, the diversification and self sustainability of energy supplies are both goals which have grown increasingly important. In particular, internationally,

[1] The installed capacity of Taiwan's Renewable Energy has increased rapidly in recent years. In 2005 the installed capacity of wind, geothermal and photovoltaic power combined together was only 24.9 MW, in 2006 this reached 105.1 MW, 2007 190.1 MW and by 2008 it has already grown to 257.7 MW [1].

[2] Taiwan renewable energy power generation has grown rapidly in recent years from a combined total of 92.2 Gwh for wind, geothermal and photovoltaic power in 2005, to 278.8 Gwh in 2006, 445.7 in 2007 and 593.5 Gwh by 2008. Wind power grew the most rapidly of these three forms of renewable energy; 91.3 Gwh in 2005, 277.4 Gwh in 2006, 443.6 Gwh in 2007 and 589.3 Gwh by 2008. While photovoltaic power still has a lot of room for improvement; the total power generated by photovoltaic power in 2005 was only 0.9 Gwh, in 2006 this rose a little to 1.5 Gwh, and again to 2.2 Gwh in 2007 and in 2008 it grew by almost double yet still remained low at 4.2 Gwh [1].



Year	1993		1998		2003		2008	
Thermal	74,131.6	64.35%	115,754.0	70.93%	163,261.5	78.09%	189,133.3	79.36%
Hydro Power	6,718.8	5.83%	10,607.9	6.50%	6,896.5	3.30%	7,772.3	3.26%
Nuclear Power	34,354.2	29.82%	36,824.5	22.57%	38,889.6	18.60%	40,826.9	17.13%
Solar	0.0	0.00%	0.0	0.00%	0.5	0.00%	4.2	0.00%
Geothermal	1.4	0.00%	-	0.00%	-	0.00%	-	0.00%
Wind	0.0	0.00%	0.0	0.00%	13.8	0.01%	589.3	0.25%
Total	115,206		163,186		209,062		238,326	

Fig. 5. Power generation graph.*Data source*: MEA [1].

in response to the challenges of climate change; strengthening energy-related scientific research, developing new energies and renewable energy industries have as a result become a new trend. In light of the dual conditions which have arisen from this critical moment in time: this new wave of international economic competitiveness in industrial development on the one side and an international push towards greater energy self sustainability on the other, mean that for Taiwan developing self sustainable green energy has already become an unavoidable future goal.

3. The situation for renewable energy development in Taiwan

In fact, in order to improve the security of energy supplies, decrease CO_2 emissions while simultaneously considering the demand for energy to support economic development. The energy policy pursued by the Taiwan government in recent years has emphasized stable energy supplies and improvements in energy efficiency as its main strategies: with developing alternative energy sources and energy diversification as its two main strategies. In particular, following two oil crisis, the Industrial Technology Research Institute (hereafter ITRI), Taiwan Power Company and the Chinese Petroleum Corporation began to carry out research into renewable energy technologies. While from December 1997 after the signing of the 'Kyoto Protocol', the Executive Yuan took the next step by holding three National Energy Conferences in 1998, 2005 and 2009, respectively. Most recently in June 2009 Taiwan's Congress passed the 'Renewable Energy Development Act' with incentives to promote the increase the generated installed capacity of renewable energy to at least 6.5 G. According to the 'Sustainable Energy Policy Principles' passed in 2008 the Ministry of Economic Affairs and National Science Committee both planned to lead flagship projects in the coming year, the names of which are the 'New Energy Industry Flagship Project' and 'National Projects of Energy Technology', respectively. They have a 20 billion budget to invest over 5 years of at least 200, to attempt to encourage breakthrough in Taiwan's current development dilemma in both industrial and R&D.

In recent years, in terms of real investments in Taiwan's renewable energy technology and industrial investment, other than Taiwan's hydraulic power development having been persistently led by Taiwan Power Company; while photovoltaic, solar thermal and wind energy also stand out as areas where investment and time has been spent; domestic power generated installed capacity, industrial capacity and market demand are all comparatively high. Other than this, in terms of biomass energy, geothermal energy, ocean energy and other newly developing energy technologies which are considered to possess development potential, the government has also made an effort to encourage technological R&D and policy planning.

3.1. Solar power (solar thermal power, photovoltaic, etc.)

Taiwan is a sub-tropical; with abundant sunlight therefore there is great potential for harnessing both solar and solar thermal power. Currently the main use of solar thermal power is in Solar Thermal Systems, the technology is also comparatively well practiced; there are also solar thermal power refrigerating and in Taiwan between 94 and 96% of households currently use water heaters. In fact as early as the 1980s, Taiwan made efforts to encourage the people to install solar thermal systems for heating water and so on, according to the 'Incentives for Promoting Installation of Solar Thermal Water Systems Measure', subsidies were offered to civilians willing to install such a system and successfully promoted solar thermal energy on the domestic market, making Taiwan third in the world for installation density [3]. However worthy of note is that the incentives being offered to promote an increase of the total amount of installations in the 'Renewable Energy Development Act', does not include solar thermal power, but only authorizes the Central Committees Bureau of Economic Affairs to set installation targets. Up until 2008 Taiwan's total accumulated solar thermal water heater installations covered a combined space of 1.787 million square metres, yet its growth rate is much lower than the global growth rate.

Domestic photovoltaic technology is already increasingly mature, and along with LED lights, has become one of the main green industries supported and fostered by the government [4]. In 2008 the overall output value of the photovoltaic market reached new heights at 101.1 billion TWD, with a growth of 89%, the production levels and capacity for photovoltaic batteries was fourth highest in the world, accounting for 16.7% of global production; however, at the moment 98% of the photovoltaic battery industry is dependent on exports [5]. Currently there are the following numbers of factories: 6 Silicon Wafer factories, 16 Silicon Battery factories, 12 Thin-film Cell companies, 15 module companies as well as another 20 downstream system and application factories, bringing up the total to over 70 [1]. However, despite the government promising to use all its power to develop Taiwan's own Photovoltaic industry, and the investment incentives offered in the 'Renewable Energy Development Act', Taiwan's photovoltaic industry still faces many problems, such as: technology innovation and reform issues, small demand in the domestic market, a shortage of silicon primary materials, authentication and standards are still not in place, a deficiency in the complete industrial chain.

In terms of technological R&D, other than Taiwan's photovoltaic industry which has taken advantage of Taiwan's already well

developed semiconductor technology and invested its full strength in developing silicon wafer style photovoltaic battery technology and improving efficiency. Compound thin-film cells, dye-sensitized solar cells, silicon thin-film and concentrated III–V solar cells are all examples of this generations innovative technology as well as being the key focus of industrial and government investments for further R&D. Overall, other than the government's promise to invest 20 billion TWD over five years to develop renewable energy technology, annual investment in photovoltaic R&D is in reality far behind that of its European counterparts [6]. Current R&D projects are again nothing in comparison with those of more advanced economies; lacking in diversity and potential for significant technological breakthrough. In terms of broadening the base of the domestic market, the government has implemented a financial incentives scheme for installing photovoltaic model systems, through the 'Renewable Electricity Feed Principle' beginning in 2003. They offer inducements to encourage the domestic market to increase installations, while also adding impetus to various model promotional schemes including, 'Photovoltaic Roofing' (2000–), 'Photovoltaic Community', 'Photovoltaic Walling' (2004–2006). According to resources found at the Industrial Technology Research Institute of Taiwan's Solar Center, the total number of photovoltaic system installations completed in 2008 totalled 385 cases, installation capacity reached approximately 5 MW (including Kaohsiung Olympic Stadium) and following the formal implementation of the 'Renewable Energy Development Act', it is estimated that the prevalence rate for domestic photovoltaic systems will increase to the extent that by 2012 domestic installation capacity can reach 60 MWp. However the structural changes occurring in the photovoltaic market deserve our taking a closer look.

3.2. Wind power

Taiwan is an island nation in the sea, with coastal region in all four directions and the potential for harnessing wind power. Other than onshore wind power, offshore wind power has the potential to harness wind power which could reach as much as 1.2 GW [7]. Add to this the fact that basic costs for harnessing wind power are comparatively low in comparison with other forms of renewable energy and it becomes clear that Taiwan is highly suited to develop wind power energy. Onshore wind power is limited by the gradually decreasing number of suitable sites avail to allocate for this purpose, and therefore preparing offshore wind power sites with stable wind sources, low level wind shear and large in size could be a key area for R&D in the coming years. The Ministry of Economic Affairs Energy Committee (predecessor to the Bureau of Energy) as early as 2000 had already begun promoting wind power electricity and related model schemes: formulating the 'Wind Power Model/Demonstration System Installation Subsidy Principle', though this scheme came to an end in July of 2004, during its period of implementation it provided installers with 50% of all installation costs [8]. By the end of July 2004, Yunlin, Penghu and Shaobei had all completed installing model wind power installations with a combined total installed capacity of 8.54 MW. This first step encouraged a general mood of acceptance for installations of domestic onshore wind power systems. From July 2002 Taiwan Power Company also continued in initiating schemes to generate power form wind power; the first period was from 2002 to 2008, the second from 2004 to 2010 and the third from 2006 to 2011. They also funded an offshore wind power scheme near Jinmen. According to the Industrial Technology Research Institute of Taiwan Energy Center's statistics, at the beginning of 2009 the combined installed capacity of wind power generated power system installations operating through Taiwan's electricity industry had reached 161.76 MW, this does not include the accumulated capacity of other wind power businesses and the overall installed capacity of the generated power from Taiwan's wind power systems is 358.2 MW [9].

In terms of the domestic industry for wind generated power, there are only a handful of factories and businesses currently involved: Taiwan Renewable Company, Ltd., InfraVest GmbH and a few other companies; in 2008 this industry was still worth less than 3.5 billion TWD [10]. The development of domestic wind power technology is still at the stage of developing key component technologies. Besides having already successfully produced wind generators, towers and other components, blades, gearboxes and electricity converter systems have also been developed to the point that these companies possess the capacity to produce the technology themselves. However, Enercon, the wind turbine manufacturer used by InfraVest GmbH and other companies during installation is not based in Taiwan and therefore in terms of wind power components and products there still remains a lack of accumulated experience in self manufacturing capacity domestically [11]. As a result, the wind power industry's current stage must be opened up and developed to produce key technologies, broadening domestic demand and through forming alliances within Taiwan's wind power industry create a wind industry organization which can then work in cooperation with others internationally [12], and in turn continue to broaden the wind power market abroad too. Moreover, R&D into wind generated power technology is also in need of wind energy assessment technology. This would include Wind generated power turbine technology and an improvement in onshore/offshore MW wind turbine self manufacturing rates in order to increase the future development of offshore wind power installation technological capacity, with a vision that by 2015 Taiwan's wind power market will be worth 12.45 billion TWD.

3.3. Geothermal energy

Taiwan has a wealth of hot springs within its borders, which are spread around the whole island from north to south and east to west with 26 different sites altogether. And all of these hot springs possess a rich wealth of geothermal resources which all added together have the potential to generate approximately 500 MW of power. The government as early as 1961 when the Tatun Volcano Group carried out surveys, however the follow up discovered that the water quality in this area possessed sulfur oxide, which has the potential to cause corroding to installation piping which needs overcoming through technological innovation. The National Science Committee and Ministry of Economic Affairs in the 1980 set up geothermal power plants on the East coast at Chin-Shui and Tu-Chang; with the Taiwan Power Company and Chinese Petroleum Corporation leading the operational work the installation capacity reached 3 MW and 0.3 MW, respectively. However problems with inefficient operating along with the expiration of the plans original set times, meant that in the end they both stopped operating in quick succession [13]. In order to reinitiate geothermal related research, the Ministry of Economic Affairs in August 2008 announced the, 'Geothermal Power Model System Survey Subsidy Principle' and encouraged the people themselves to participate in developing surveys into geothermal resources and technological research. Currently, Yilan and Taitung County governments are responsible for geothermal power planning; carrying out 'multiple use' along with the BOT style. Yilan County governments plan is called 'Clear Water Area Hot Springs Water Power Use Plan' [14], and sets its installed capacity goal at the early stage as 5 MW, planning within five years to have an installed capacity of 10 MW, while Jin-Lun, Taitung geothermal area also established a 'geothermal model area', which will become the first domestic business operating geothermal power plant.

3.4. Ocean energy

Besides the developing maturity of wind, solar and biomass energy, which currently account for the majority of renewable energy in Taiwan, with the ocean surrounding Taiwan in all directions, ocean energy also possesses great potential for developing. Ocean energy can be separated into four main areas ocean thermal energy, tidal power, marine current power and wave power but the majority of Taiwan's early research into this field has been based on ocean thermal energy alone and overall, Taiwan's development in this field is comparatively backward and undeveloped, still remaining in the 'potential survey' stage [15]. In terms of Taiwan's potential for developing ocean energy, according to surveys carried out by the ITRI, due to the similarity in the tide around the coast of Taiwan, the lack of fiord and the small size of the islands various harbours, therefore there is little value or potential in developing tidal power. As for wave energy, the temperature difference of the ocean and marine current power means that there is an estimated harnessing power of one hundred MW or more of installed capacity. The East Coast of Taiwan's potential marine current power (black tide) possesses the potential to exploit even more GW in installed capacity than this. Although the set up incentives in the 'Renewable Energy Development Act' include ocean energy, however due to the fact that technological R&D and special financial support policies are currently not in place, therefore ocean energy still remains relatively unexplored in Taiwan.

In terms of industrial investment, there are a number of companies currently exploring the potential of obtaining deep ocean water (related to ocean thermal energy technology) [16], although this is not directly related to power generation, in the future however if combined with ocean thermal energy, it could provide useful technology and improve the economic effectiveness of operating ocean energy [17]. Moreover, current R&D progress on the technology needed for ocean thermal energy has yielded more fruitful results. The Industrial Technology Research Institute in 2006 successfully developed a small scale low temperature ocean power generating system. However, R&D into wave and ocean current power generation technology remains in the early survey stages, while research into power related equipment and structural installation technology is also relatively weak [18]. In short, the time spent exploring the potential of ocean energy domestically is comparatively short; however, if the government repeats the cycle of incentives and investments which it used to develop photovoltaic technology, with a framework of subsidies, laws, regulations and policies, international cooperation and self developed and manufactured technology, strengthening potential energy assessments and cooperation with other industries [19], then Taiwan could overcome the current dilemmas being faced in both the technological and investment environment and advance exploration and development of Taiwan's ocean energy industry.

3.5. Biomass energy

Since being incorporated into the 2009 'Green Energy Industry Sunrise Program', biomass energy is now officially one of the main items on Taiwan's agenda for renewable energy in need of industrial development. The government's aim is that by 2011 bio-diesel and gasohol will have a combined generated power of 741 MW. Moreover, the main goal of developing biomass energy is to create a more environmentally friendly fuel; reducing the amount of green house gas produced by transportation vehicles and in particular the high levels of CO_2 emissions. In this way biomass energy can truly provide the domestic market with an effective method for 'economizing fuel, reducing CO_2'. Taiwan's main market demand for biomass energy is for bio-diesel and bio-ethanol, while bio-hydrogen energy still remains in the basic developmental stages, however the fruitful results of R&D should not be neglected. In terms of this developing environment, with its small land mass, Taiwan has a limited amount of agricultural land for developing biomass projects. Besides an insufficient supply of waste edible oil, sun flower, soy bean, kidney bean and other primary materials, the cost of producing biomass energy is considerably higher than in other countries, and this can only be overcome through a greater degree of international cooperation and a new generation of technology (i.e. lignocellulosic materials) to enable improvements to be made during development [20].

Through observing the current stage, we can know that Taiwan only has a handful of companies investing in the biomass industry; the combined annual production level of bio-diesel is currently at 16,300 tons; as for bio-ethanol energy, only state owned enterprises are currently investing in its development with a planned annual production of 460,000 tons. Since 2007 the Taiwan Sugar Corporation has begun to increase production and estimates that by the end of 2009 it will have increased bio-ethanol levels up to 150 kilolitres [21]. In terms of the production chain within Taiwan's biomass industry, besides the insufficient supply of primary materials upstream, the midstream (production) and downstream (supplying service) stages also face the same challenge as that in the photovoltaic and wind power industries, which is that key technologies and equipment come from outside Taiwan's own market and this is an aspect with needs to change. As for biomass technology, besides the ITRI continued exploration of bio-diesel manufacturing systems, there needs to be continued R&D into bio-hydrogen, enzymes, micro-algae, lignocellulosic ethanol and thermal pyrolysis which are all important parts of the bio-diesel manufacturing process all [22]. This can also be combined with Taiwan's slightly more developed field of genetic modification technology.

In 2006 the government began to implement a number of subsidy policies aimed at supporting the development of biomass energy; through 'Green Bus', 'Green County' and other government subsidies, they attempted to give greater impetus to this new field. Their short term strategy involves nurturing demand within the domestic market in order to support the industry. However currently the market supply is insufficient to satisfy demand, which means waiting; waiting for officials, academics and other actors to coordinate in harmony with one another to speed up the process to broaden biomass energy's installed capacity.

3.6. Small scale hydropower

Taiwan's hydropower energy can be separated into various groups in accordance with their installed capacity and operating model: Large scale (an installed capacity of more than 20 MW), small scale hydropower (less than 20 MW), conventional hydropower, pumped storage hydropower and so on. The environmental controversy surrounding large scale and pump storage turbine hydropower at present remains intense and as a result the government has turned its attention to exploring the potential of small scale hydropower resources. Small scale hydropower, referring to water generating power systems with an installed capacity of less than 20 MW, can be used for powering irrigation channels and drop heads. According to estimates from the Taiwan Power Company, hydropower's overall explored potential is approximately 1090 MW, while the domestic installed capacity from all forms of hydropower is currently at 183.2 MW. The Energy Bureau at the Ministry of Economic Affairs plans that by 2010 this figure will have reached 207 MW and that by 2025 it will have continued to grow to 322 MW. Following the setting up of a new power plant in the south of Taiwan with private capital in 2002,

there has been continued investment using the BOT investment approach to establish small scale hydropower plants [23].

4. The background and development of Taiwan's energy policy

4.1. Before the first national energy conference in 1998

Before 1968, the petrochemical industry policies pursued in Taiwan promoted the building of industrial chains through economic development plans; the very promotion of which caused the government to gradually begin to realize the contradiction existing between economic development on the one side and energy security on the other. In September 1968 the 'Taiwan Energy Development Principles' were formulated and clearly set six basic guidelines: new energy exploration and development; energy diversification; improve energy efficiency; decrease cost; reduce tax on imported energy and energy price policy and a number of other items. These principles also established the fundamental direction by which all future energy policies have been formulated. The item on exploring and developing renewable energy sources at that time was mainly focussed on hydropower, geothermal and bagasse. In the 1970s as the world experienced the energy supply shortage crisis, the government's Energy Policy deliberation group in April 1973 drafted the 'Taiwan Energy Policy' which emphasized energy diversification, spreading out the locations of new power plant sites, economize energy, energy prices, energy sustainability, energy research and so on. After this in 1979 following the completion of the first revisions to this policy, the policy also included plans to: establish an energy specific institution (Ministry of Economic Affairs Energy Committee), allot funds for a concrete scheme to support China Petroleum Corporation and Taiwan Power to conduct R&D into alternative energy resources [24]. In particular in terms of renewable energy, this policy increased the funding source for Taiwan's alternative energy R&D.

As for practical action, the Industrial Technology and Research Institute, China Petroleum Corporation, Taiwan Power and other related companies began to actively invest in renewable energy technological R&D. At that time the main focus of R&D had already moved towards biomass and solar energy, as well as exploring potential geothermal sites and the first stage of technology assessment. Altogether the 'Taiwan Energy Policy' has been through four stages of revisions [25]. Revisions were made in response to the different crisis and disputes which occurred throughout the past few decades; the oil crisis, Falkland Islands war and 'Climate Change Outline Treaty' of 1997 to name just a few, each affected Taiwan's own national policy and demonstrates the effect of global developments and trends on domestic policy [26].

4.2. 1998 National Energy Conference

The third ratification of the 'Climate Change Outline Treaty' was held in Kyoto, Japan, where the 'Kyoto Protocol' with its commitment to reduce greenhouse gas emissions was signed. Two different reduction requirements were set based upon six items of greenhouse gases. In order to respond to this, the Executive Yuan held the first 'National Energy Conference' in 1998. The five main points stated in the final summary from this conference were: 'Climate Change Outline Treaty: Trends, Response and Countermeasures', 'Energy Policy and Structural readjustments', 'Industrial Policy and Structural adjustments', 'Energy efficiency and S&T development', 'Energy Policy Tools' [27]. The Ministry of Economic Affairs' Energy Committee also edited the 'Energy Policy White Paper' focused on the energy policy before and after the conference, the current development situation and future development prospects; it proposed a deep and thorough implementation of these policies' program. This conference not only affected the formulation of the 'Oil Management Act' and revisions made to the 'Electricity Industry Law'; increasing the speed of privatization of the petroleum power industry, while at the same time requiring energy saving measures to be made in the Departments of Electricity, Industry, Transportation and Housing (energy savings of 16% by 2010) and setting targets to improve overall energy efficiency (1997–2010 annually improve by 1.2%), re-planning industrial structuring and stipulating CO_2 reduction targets (2020 reduce CO_2 emissions to the standard of 2000).

As for renewable energy, the summary from the conference clearly stipulated that: (1) By 2020 the installed capacity from renewable energy sources should make up 1–3% of all energy; (2) Over a 5 year period prepare to allot 10 billion TWD investments in energy related S&T research, including new energy and clean energy R&D; (3) Energy development funding to be invested by Taiwan Power and China Petroleum at 0.5% of their individual income generated[3]; (4) Renewable energy incentives, subsidies and promotions as well as special tax treatment.

After the conference, policy tools and model plans related to the developing of renewable energy were successively put into operation including a five year 'Renewable Energy Model Promotional Plan' which began in 2000 and subsidy plans aimed at solar thermal, photovoltaic and wind power. Moreover, in 2002 the Executive Yuan issued for the implementation of the 'Renewable Energy Development Plan', continuing to add impetus to the various model system plans related to various renewable energy forms. In terms of targets for increasing the proportion of power being generated from renewable energy sources, in June 2003 at the 'National Non-Nuclear Home Conference Resolution' demanded that the Ministry of Economic Affairs bring forward to 2010 the target of renewable energy accounting for 10% of all generated power. During this 'Post 1998 National Energy Conference' period, the Ministry of Economic Affairs also began to refer to international laws and regulations, drafting the 'Renewable Energy Development Act' which then went before the Executive Yuan for consideration, before finally being passed by the National Congress in June 2009.

4.3. The 2005 National Energy Conference

In order to respond to the demands of global energy and environmental treaties, in 2005 Taiwan held its 2nd National Energy Conference which mainly focused on the problems and response strategies which should be adopted to respond to the 'Kyoto Treaty' coming into effect [28]. The content of the conference was divided into six major issues including the 'Integral Strategy Direction', 'Energy Policy and Structural Development', 'Green Energy Development and Improving Energy Efficiency', 'Department of Industrial Technology Response Strategy', 'Department of Transportation Response Strategy' and 'Department of Housing Response Strategy' for after the 'Kyoto Protocol' came into effect. Of all the issues discussed during the conference, obvious emphasis was made to the discussion of renewable energy. The conference summary proposed a number of concrete plans based on the main concerns listed below: (1) Greenhouse gas management mechanisms: formulation of statutes, CO_2 trading, energy taxing or CO_2 tax; (2) Improve energy efficiency (annual increase of 2%) and energy structure; (3) Revise and Invest in 'Energy Management Act' planned norms; (4) Green transportation system and LED signals; (5) Energy efficiency

[3] For details see Energy Management Law, 5th Article 1st Item and Energy development Fund: Regulations related to the receipts safekeeping and operational methods.

standard norms and green architecture urban planning control mechanisms; (6) The construction of the Taiwan's 4th Nuclear Plant. However the failure of those during the conference to set concrete targets for reductions of CO_2 emissions, gave rise to considerable criticism from environmental groups.

In terms of renewable energy, the 2nd National Energy Conference held in 2005 set a number of targets: (1) renewable energy should account for 4–6% of all energy by 2020 and 5–7% by 2025; by 2020 Taiwan's renewable energy installation portfolio should have grown to 10–11% and by 2025 10–12%; (2) The overall power generated by renewable energy sources was set to rise to 5 GW by 2010 and 7–8 GW by 2020; (3) Improve and develop various renewable energy sources in accordance with their installed capacity; (4) Broaden demand for renewable energy within the domestic market; (5) Plan the National Energy S&T Program, increase R&D financing and integrate energy technological R&D; (6) Advance the legislative process for the 'Renewable Energy Development Act'.

From examining the implementation of the plans and programs set out at the 2005 National Energy Conference, from after the conference had finished up until the end of 2008, one can identify the areas where certain departments have been more successful in implementing the changes stated at the conference: there has been an improvement in energy savings, emission reductions, natural gases used and the petroleum industry has been privatized. At the same time it is also clear to see that overall energy consumption is still increasing at a rate of only 6% a year, which is way behind countries such as Germany, the U.S. and Japan [29]. While in terms of the rationalizing of energy prices, reducing greenhouse gas emissions, revising the 'Energy Management Act' and energy tax, there still remains a lot of room for improvement. As for industrial development and drive, the Energy Bureau beginning in 2007 has implemented successive model plans on 'Green County', 'Green Buses' (biomass energy) and other similar initiatives. Moreover taking photovoltaic industry development strategy as a discussion point and setting principles, adopting photovoltaic, wind and biomass as the key areas for industrial development, in particular in terms of wind development, this can be seen with the '1st Stage Installing Offshore Wind Power Turbine Plan' which was initiated in August 2008.

4.4. Executive Yuan 2007 Industrial S&T Strategy Meeting

The highest policymaking mechanism in Taiwan in determining S&T development, the Science and Technology Advisory Group of Executive Yuan, in 2007 held a meeting of the Strategic Reviewing Board (SRB) on the issue of industrial S&T. This meeting was concerned with discussing possible energy saving technology, renewable energy S&T and forecasting energy technology. These issues were discussed in terms of how they could be incorporated into Taiwan's development strategy; in light of global energy technology and industrial competitiveness faced by the Taiwan government in recent years, this meeting was an opportunity to carry out vital planning for the future [30]. In terms of Taiwan's renewable energy policy, it was proposed that domestic renewable energy resources should be used to provide a self sustainable, supportive power source, broaden domestic demand and increase the applications of new technology models, with the aim of constructing in Taiwan a renewable energy industry which is able to be competitive internationally. In terms of targets for the installed capacity of power generated: by 2010 installed capacity for power generated from renewable energy should have reached 3.91 GW, accounting for 10.3% of total installed capacity; in 2015 this target should increase to 4.972 GW or 11.2%; by 2020 it should increase again to 8.45 GW or 14.9%. These are important targets towards which the Taiwan government is currently working to promote renewable energy.

Taking these most recent targets as a standard, this paper will examine the current situation of Taiwan's various renewable energy sources and their current installed capacity, besides conventional hydropower, geothermal energy which is currently under R&D and ocean energy, in 2008 the total installed capacity of wind and photovoltaic generated power was 358.2 MW and 5.6 MW, respectively, which means that altogether the total installed capacity of renewable energy has only reached 2.97 GW, which accounts for 6.4% of all power generated installed and only approximately 5% of gross power generation. Meanwhile self-produced energy, including renewable energy accounts for less than 1% (approximately 0.66%) which is a far cry from the 2010 target of 3.91 GW of power generated installed capacity and 10.3%; and is currently waiting for a proverbial push from the governments.

4.5. 2008 'Sustainable Energy Policy Outline'

In 2008 with a new government in power, in order to maintain impetus and practically implement sustainable energy policy development, the Executive Yuan in June of the same year proposed a 'Framework for Taiwan's Sustainable Energy Policy' which set a target of 'environmental protection, energy and economy triple win', while also proposing a 'two low' 'two high' principle to practically fulfil the following tasks: (1) improve energy efficiency; (2) develop clean energy; (3) economize on various department's energy consumption; (4) construct energy related laws and regulations. In relation to the goal to develop clean energy, national CO_2 emission reduction rates were set, which include between 2016 and 2020 returning to the 2008 emission rate and by 2025 returning to rate of CO2 emission in 2000. Moreover, by 2025 low carbon energy and power generator systems should account for 55% of the gross power generated, an increase of 15% from the current 40% percentage.

There were also a number of targets set related to renewable energy: by 2025 renewable energy should develop to account for 8% of all power generated (this target is higher than that set in 2005 at the National Energy Conference); the pace for the 'Renewable Energy Development Act' legislature should be increased; finances for energy related research should also be increased. From a comparison of these two government policies, while the outline proposed by this government reset targets for greenhouse gas reductions, they remain lower than those set in the 'Kyoto Protocol'. With Taiwan's obvious position as a high energy intensive nation, future revisions to these targets are still necessary. Moreover, the Executive Yuan in September 2008 also made revisions to the related 'Energy Saving Reducing CO_2 Action Plan' in order to carry out the procedures and measurement targets set out in the framework above.[4]

4.6. 2009 National Energy Conference

At the 2009 Energy Conference the main issues up for debate included: (1) Sustainable Development and Energy Security; (2) Energy S&T and Industrial Development; (3) Energy Management and Increasing Efficiency; (4) Energy Prices and Open Market [31]. The main discussion points during the drafting of energy related policy are those of: CO_2 emission reduction targets; decreasing of the highly concentrated nature of energy; new energy, energy saving and CO_2 emission reduction technology; integrated S&T

[4] Executive Yuan Environmental Protection Agency again on 4th June 2008 implemented 'Saving Energy Reducing Emission No Regrets Measure National Action Plan', promising to persist in promoting related legal measures.

Table 1
Taiwan promotion of renewable energy installation subsidy policies.

Central committee	Subsidy policy and related laws and regulations	Administering unit and time period
Ministry of Economic Affairs (MEA)	Solar Thermal System Promotional Incentive Principle and Related Operational Guidelines	Energy Bureau (2003.02–)
MEA	Photovoltaic Power Generating Model System Installation Subsidy Regulation	Energy Bureau (2000.05–2002.03)
MEA	Photovoltaic Power Generator Model System Installation Subsidy Principle	Energy Bureau (2002.03–2006.07)
MEA	Photovoltaic Power Generator Model System Installation Subsidy Principle	Energy Bureau (2006.07–)
MEA	Wind Power Generating Model System Installation Subsidy Measure	Energy Bureau (2000.03–2003.02)
MEA	Wind Power Generating Model System Installation Subsidy Principle	Energy Bureau (2003–2004.07)
MEA	Taiwan Power Renewable Energy Electricity Feed Principle	Taiwan Power Company (2003.11–)
Energy Bureau, MEA	1st Stage Installation of Offshore Wind Power Generator Power Plant Scheme	Energy Bureau (2007.09–)
MEA	Geothermal Power Generator Model System Exploring Subsidy Principle	Energy Bureau (2005.08–)
MEA	Normal Waste Landfill Gas Generation Incentives Measure	Energy Bureau (2003.01–)
Energy Bureau, MEA	Ministry of Economic Affairs Energy Bureau Green Public Bus Plan Subsidy Principle	Energy Bureau (2006–)
Energy Bureau, MEA	Ministry of Economic Affairs Energy Bureau Green County Application Promotional Plan Subsidy Principle	Energy Bureau (2006–)
Energy Bureau, MEA	Ministry of Economic Affairs Energy Bureau Green Public Affair Cars Lead the Way Plan Principle	Energy Bureau (2007.09–)

development strategy; low energy consumption in the industrial structure; the legal structure of the three energy laws: 'Greenhouse Gas Reduction Act' and 'Sustainable Energy Basic Law, currently awaiting review by the Legislative Yuan; rationalization of energy pricing and market liberalization [2]. At the same time, the conference also acknowledged the CO_2 emission reduction targets set in the government's 2008 Framework of Taiwan's Sustainable Energy Policy; taking 2007 CO_2 emission levels of 268 million tons as a base, the target for 2016–2020 was to return to the 2008 level of CO_2 emissions and by 2025 to have returned to the level of CO_2 emissions in 2000 (214 million tons).[5]

In relation to renewable energy development, the conference did not set ratio targets and in a break from the past two Energy Conferences they instead discussed: (1) how to hasten the emergence of the 'Renewable Energy Development Act'; (2) the importance of prioritizing investments in green energy industries; (3) establishing green power price system; (4) integrate scientific research system (flagship new energy industries and national energy S&T plan), for mutual opinions to be accepted. At another level of analysis this conference did not continue in the suggestions made in the 2007 'Industrial S&T Strategy meeting' of setting targets for the power generated by renewable energy to account for 14.9% of total generated power, instead they backed up on government policy towards nuclear power (nuclear energy here is defined as low CO_2 energy), causing the renewable energy budget to be split between nuclear energy and renewable energy and as a result weakening the potential progress of developments in renewable energy.[6]

Having already provided a simple overview of Taiwan's annual energy policies and their contents as they related to renewable energy, a number of items provide indicators for key issues including CO_2 emission reduction levels, power generation of renewable energy and installed capacity ratio, energy concentration rate, increase energy efficiency and others which constantly alternate in importance and focus. The change in government also raises the question of whether the government's plans for developing renewable energy are already complete, which also impacts on the amount of the budget set for investing and the appropriateness of science and technology R&D items. The author will continue by discussing the government's renewable energy operating strategy for developing this field, the currents status of laws, measures and policies related to renewable energy as well as providing further explanation on the effectiveness and results and outcomes of these current measures.

[5] Only this target did not meet the standard set by the 'Kyoto Protocol', considering the fact that Taiwan's CO_2 emissions make it one of the greatest CO_2 emitters globally, the targets set by the government are highly conservative.

[6] There were 401 recommendations made during the accumulated discussion throughout the conference; in 249 of these items consensus was reached, leaving 152 items which were left as 'other opinions', a number of which were related to the problem of definitions for renewable and nuclear energy.

5. Taiwan's policy for promoting the development of renewable energy

In order to realize the national sustainable development and energy security targets the Taiwan government has actively implemented a variety of policies, tools and legal methods, to broaden the demand of the domestic market, promote industrial investment, strengthen R&D and establish a complete renewable energy industrial chain. From the government's 'Purchasing of Cars for Public Affairs Model Plan', installation subsidies and the establishing of laws and regulations for investment tax credit, tax credit and R&D financial subsidies as policy tools for developing the related industries. These various policies, measures, plans and legislative acts can roughly be separated into two parts economic and non-economic incentive policies.

5.1. Economic incentive led policies

5.1.1. Subsidies

The government provides annual funding and subsidies for various model systems for renewable energy enabling them to carry out a number of concrete plans (Table 1). Of all the various economic incentives the most successful has been the 'Solar Thermal System Promotion Subsidy Principle' and related required tasks. The 8th article clearly sets out the different regulations concerning the installation subsidy which will be allocated (1000–3000 TWD per M2), respectively, depending on whether based in Taiwan or the offshore islands. In terms of photovoltaic systems, currently in the 7th article of the 'Photovoltaic Power Generating System Installation Subsidy Principle' it states that for every kWp applicants can apply for up to 150 thousand TWD and cannot surpass 50% of the overall costs of the systems installation. Government institutions on offshore islands or in remote areas, public schools and universities provide good model results in system installations, at the most they are able to receive the whole cost in subsidies. Before this principle was implemented there already existed a similar regulation in the 'Photovoltaic Generated Power Model System Subsidy Measure' (implemented until 2004), which also provided a similar subsidy scale. However in terms of the outcome of promoting the installation of photovoltaic systems, these two administrative statutes have still not released their real full effectiveness. And the main reasons for this are the payback

period being too long, the application procedure too time consuming, there not being any obligation to transmit electricity, the Net-Metering system and the high cost of installation. By 2008, the installed capacity of photovoltaic systems was only approximately 4 MW (not including Kaohsiung Olympic Stadium) which means that the overall amount of power generated in this way is far behind that of wind generating power systems.

As for the promotion of wind power systems, in 2000 Taiwan initiated the 'Wind Generated Power Model System Subsidy Measure' which provided purchasers with a 15–20% subsidy, in 2003 this figure was increased to subsidize up to 50% of installation costs. However after the follow up to this measure 'Taiwan Power Renewable Energy Purchase Operational Principles', with its energy purchase principle which stated that the state would purchase wind generated power at a rate of 2 TWD per kilowatt, the former subsidy measure was annulled and under this changed scheme the electricity price purchase principle continued to promote the installation of wind systems. At the end of 2007, the high peak of wind power development, the amount of generated power being used for commercial purposes reached 238.3MW. Currently the development of wind power is at a stage where the limited availability of sites for installations has meant a change in direction, as a result in September 2007 the 'First Stage in installing Offshore Wind Power Plant Scheme'. Moreover, in relation to developing geothermal energy sources, Taiwan also has 'Geothermal Model System Exploration Subsidy Principle'. Currently a geothermal development plan for the Qing-Shui and Jin-Lun areas has already passed through the examination process.

As for policies promoting the development of biomass energy, the Energy Bureau beginning in 2006 initiated 'Green Buses' and 'Green County' plans (all with the purpose of promoting bio-diesel) adopting diesel subsidies or altering car fuel methods to reduce pollution, and now having already completed this first stage of the mission, article 5 of the 'Normal Waste Landfill Gas Generation Incentives Measure' includes the 'Green Public Affair Car 'Lead the Way' Plan Principle'; while article 9 which refers to bio-ethanol fuel includes the most recent drive, 'Taipei and Kaoshiung Metro Area Ethanol Gasoline Promotional Plan', offering pricing subsidies as economic incentives to users. Taiwan's biomass energy related drive is currently focussed on the interest of the larger group by attempting to promote reforms to the market and is therefore in the earliest stage of development. Fundamentally, measures currently in place for promoting biomass fuel are limited to subsidies and economic incentives and these subsidies tend towards a 'point' or a specialized department, therefore in the future appropriate adjustments and revisions must be made to this plan, in particular the introduction of energy taxes would incite the rationalization of gasoline prices and reflect the true cost of the price.

5.1.2. Tax credit

5.1.2.1. Statute for Promoting the Upgrading of Industries. Beside the price and installation subsidies, domestic law has also provided a tax remittance preferential policy for renewable energy industries, for example: tax reductions for encouraging investments, tariff remittance or increasing the speed of depreciation. While the 'Statue for Promoting the Upgrading of Industries' is the most important legal standard, other laws and regulations including: 'Company Purchasing Economizing Energy or Using New Clean Energy Facilities or Technology Investment Reduction Measure'. The main incentives offered in both the 'Statute for Promoting the Upgrading of Industries' along with the 'Investment Reduction Measure' are: (1) Up to 13% support for facilities, receive tax credit on all tax from profit making business; (2) Receive tax credit on between 10 and 20% of cost of investment in industry's stock market; (3) Two year increase in speed of depreciation; (4) Low interest loan and so on. While in terms of tariffs, of most concern is article 9 of the Statute which stipulates, 'tariff free imports of equipment not produced domestic' and is limited to equipment for industrial use.

5.1.2.2. Renewable Energy Development Act. Within the 'Renewable Energy Development Act', it also states that if industries 'imported supplies for the construction or operating of renewable energy power generating facilities or components (which are not manufactured domestically) should be tariff free'. It therefore seems to naturally follow that if individuals importing renewable energy power generating facilities which are not manufactured domestically, they should also be tariff free and extend this tariff free incentive, broadening it to include normal citizens. However, this article of the 'Statute Promoting Upgrading of Industries' will cease to be effective at the end of 2009, and the Executive Yuan is currently picking up the pace on the legislation task for the 'Statute of Industrial Innovation', using measures that link favourable incentive; of which those related to the investment tax credit and subsidies of renewable energy industries, roughly are R&D expenditure investment tax credit and fiscal transformation. In the future, besides the 'Renewable Energy Development Act' this law will become the key legislation in Taiwan's renewable energy industry, and the key to legally supporting the transition from manufacturing based industry to 'Service based Industry'.

5.1.3. Electricity feed-in tariffs

5.1.3.1. Renewable energy electricity feed-in. In relation to Germany's Renewable Energy Law (EEG) already longstanding Electricity Feed-in Tariffs, Taiwan since 2003 announced 'Taiwan Electricity Company Renewable Energy Electricity Feed-in Principle' and in coordination with the 'Ministry of Economic Affairs Elected Renewable Energy Electricity Feed-in Target Principle' providing a renewable energy electricity Feed-in tariff of 2 TWD per kilowatt of electricity and setting an upper limit of 600 MW on the total capacity of renewable energy generated power, excluding waste incinerators and hydropower systems generating above 20 MW. However with the implementation of this principle, a combination of factors including the feed-in tariff prices being too low to attract investors, insufficient obligation to transmit electricity and so on, have meant the economic incentives offered were insufficient and in the case of industries generating wind power it has given rise to an intense rebound. In comparison to other feed-in tariff prices such as Taiwan Power's feed in tariff of 5 TWD a kilowatt for natural gases or with other countries' renewable energy feed-in tariffs (such as Germany or South Korea) which offer feed-in tariffs of over 15 TWD per kilowatt, Taiwan's renewable energy feed-in tariff prices still don't reflect the rational cost; these prices therefore need re-examining and adjusting to reflect the cost of renewable energy in real terms.

5.1.3.2. Renewable Energy Development Act. For this purpose, each item in article 9 of the 'Renewable Energy Development Act' is aimed at feed-in tariffs, stipulating the need for a Fee Review Committee to be set up and the re-examination of renewable energy power prices to be carried out at an appropriate time, and this new price should not be lower than the average cost of fossilized fuel generated power in the domestic electricity market. This Fee Review Committee's legitimacy should be established on the converged opinions of those from various different fields; and this is the key to determining an appropriated electricity price. In turn this will affect the range of Taiwan Power Electricity prices (the renewable energy generated power purchased by Taiwan Power is in turn transferred to customers through the mainframe).

Currently various electricity prices are not firmly established, but the Executive Yuan estimates that photovoltaic generated power should have a feed-in price of at least 8 TWD a kilowatt, while wind generated power should be at least 2.5 TWD a kilowatt and potentially even as much as 4 TWD. In the future following the formulation of set electricity prices, Taiwan can also cooperate to establish a net-metering system like in the U.S., creating a more mature feed-in tariff mechanism. Besides enabling the industry a rational profit earn space, it is also another step in stimulating greater public participation. From the perspective of public, feed-in tariff electricity prices being either too high or too low are not conducive, if the former it will lead to the inflation of Taiwan Power's electricity prices, while the later will not provide sufficient economic incentives to incite the public to invest in renewable energy. In the future, when determining these electricity prices, it will be vital to consider all of these factors in order to avoid depriving the government's renewable energy development plan of its supporters, its potential to reduce greenhouse gases as well as the opportunity to stabilize the domestic supply of energy.

5.2. Non-economic incentive policies

5.2.1. Technology R&D incentives

At present domestic promotion of renewable energy is mainly based on incentives and subsidies as its main policies, however the government besides participating in investing and leading in heavy investment plans, has in recent years also begun to actively invest in research into renewable energy S&T. The earliest legal reference to renewable energy R&D in Taiwan was in the 5th article of the Energy Management Law, stipulating: 'the Central Committee in accordance with the Budget Act's regulations, should set up a fund for energy related research development, formulate a plan, strengthening energy related research development'. However the origin of the majority of funding for the energy research development fund is for research into the electricity industry or petroleum which possesses higher revenues (the electricity and petroleum must invest 0.5% of their total income back into research and development) or the petroleum fund, as the research conducted through these two organizations often overlap.

The 7th article of the 'Renewable Energy Development Act' goes one step further in stipulating the need for a 'Renewable Energy Development Fund' to be set up, which could include planning subsidies and R&D applications. Since the beginning of the 1990s the overall energy R&D funding provided by the government is worth more than 1 billion TWD a year. Before 2008 this figure had reached 5.2 billion TWD however in comparison with the amount spent by the governments of other more advanced countries, this figure is still insufficient. Added to this the amount of that 5.2 billion TWD allocated to finance R&D into renewable energy technology is relatively small, in 2004 it only amounted to a little more than 0.4 billion TWD. When we consider that South Korea invested 6.0 billion TWD into renewable energy R&D in 2008, Taiwan investment in this aspect of R&D seems to be in serious short supply. At present with the Ministry of Economic Affairs, 'Green Energy Industry Sunrise Plan' plan to invest nearly 5.0 billion TWD a year on R&D there is hope for there to be increased pace of development and breakthroughs in this field.

5.2.2. Educational propagation

In accordance with the revisions made in 1996 to 'Taiwan's Energy Policy', for the first time the 'promotion of educational propagation' was incorporated into Taiwan's energy policy as a sixth guiding principle. In 1998 the contents of the 'Energy Policy White Paper' again emphasised the promotion of renewable energy education propagation. The Ministry of Economic Affairs Energy Bureau conducted energy education propagation aimed at the general population and campuses; at the same time they also set up energy education in Primary schools, educating people on the effectiveness of photovoltaic energy. The Taiwan Power Company have also planned a 'Photovoltaic 1st Stage Plan' which will run between 2008 and 2011, to install photovoltaic power generating systems in both their own factory sites as well as those factory sites provided by others, with a total installed capacity of approximately 10 MW. According to this plan, Taiwan Power chose an effective educational propagation method, selecting a number of elementary and middle schools to install solar power as demonstration sites for renewable energy education, signing agreements for a length of 20 years. Moreover, in terms of renewable energy educational propagation at high school and university, the Ministry of Education is currently drafting 'Green University' indicators; these indicators besides strengthening university campuses own environmental protection policies, it will also increase individual universities fostering of talent in the areas of energy and environmental.

5.2.3. Investment participation

In recent years Taiwan's government has already begun work to promote the establishment of renewable energy facility systems through public construction projects. Take for example Photovoltaic Energy, in Hualien city the government has already planned a 'photovoltaic city', while on the two banks of the Danshui River, situated in North Taiwan, is the Photovoltaic Recreation City and in 2009 in Kaohsiung city the Olympic Stadium where the World Deaf Olympics were held had specially built solar powered ceiling with an installed capacity of 1 MW. At the same time, the 2009 'Promote Economic Broadening Public Construction Investment Plan', Taiwan's government emphasized the fact that government public design should blend in with renewable energy components, along with the principle of green culture making up not less than 10% of the overall design.[7] And this 'green' spirit is now also being expressed through the Ministry of Economic Affairs; what began within the governments own inner departments has begun to affect architectural research for example which has led to the drafting of 'regulations to ensure renewable energy, energy saving and CO_2 emission reductions through architecture', as a reference for future public constructions. These policies procedures can be understood as a promise made by the government to use renewable energy in public work.

Setting up systems includes five products: Photovoltaic generated power systems, Wind Power generator system, Solar water heating systems, landfill gas generation systems and LED lights and when choosing a factory location, incorporating green concepts into the decision making process. Currently, the 1st stage of this 'green' project has an estimated 50 billion TWD, of which renewable energy accounts for a part. In summary, this promise of 'green' development, currently in the first stages of planning, still needs the construction of a legal support structure and positive tax incentives in order to promote an increase in the ratio of future renewable energy industries.

6. R&D: Government scientific research plan and financing overview

Out of all the renewable energy sources currently being developed, in recent years it is R&D into solar energy which has seen the most money invested, with biomass and wind power

[7] Promoting economic broadening of public construction investment emphasized that: 'they should abide by government engineering design adopting environmentally friendly, energy saving, CO_2 reducing green engineering methods, materials and design, to incorporate renewable energy elements and green principles to a degree of no less than 10%.'

following closely behind. From the perspective of R&D, besides industrial cost, renewable energy research is all carried out through the Ministry of Economic Affairs, Industrial Technology Research Institute of Taiwan, ROC along with a number of University departments which are funded through the National Science Committee. Moreover, the atomic energy commission which came under the 'nuclear energy research institute' in recent years has invested into renewable energy technological R&D and from 2007 spending on solar technology surpassed that spent on nuclear technology for the first time.

6.1. New Energy Industry Flagship Project

In recent years, Taiwan has proposed a number of positive and concrete strategies and plans to respond to the challenges of a green energy industry. Currently of most importance, is the 'New Energy Industry Flagship Project' which works into the area of industrial R&D and this, along with the 'National Energy S&T Plan' which emerged from the field of science and technology R&D, have become the two main engines driving the current development trend. The former, beginning at the end of 2008, began to be promoted through the Ministry of Economic Affairs with the main aim of actively developing photovoltaic electricity, the LED industry and so on, as well as assisting to promote the other six clean energy industry: wind power, bio-fuel, hydrogen energy and fuel cell power as well as power line communication and electric-powered transportation. In April 2009 the Ministry of Economic Affairs restored their 'Green Energy Industry Sunrise Project' with its clearly proposed development strategy. In 2010 the government estimated that the combined total from all their various renewable energy related budgets accounted for 8.6 billion TWD; at the same time developing technology, key investments, and outputs simultaneously have enabled Taiwan to fight back from enemy lines while also increasing the four main strategies for improving local demand in the local market and full scale new energy development industries. Besides government investment in R&D having increased many times over, planning for how to broaden local demand for the products which this supply country produces in its domestic new energy industries is also vital, therefore the Executive Yuan chose the domestic photovoltaic model area, stating during the next 4 years it will subsidize the expense of developing this new industry up to approximately 4.0 billion TWD, subsidizing photovoltaic ceiling, water heaters, hydrogen energy, biomass energy, electric cars and soon. Moreover, in coordination with the requirement that public works should possess not less than a 10% aspect of green architecture which is promoted in the 'Economic Promotion to Broaden Public Construction Investment Plan' mentioned above, the government can be seen to be directly promoting the development of the renewable energy industries.

6.2. National science and technology program on energy

Of the National Energy S&T Plan which will come into effect in 2010, the National Science Council will be responsible for resources integration, sifting out the key areas of energy development in order to supplement Taiwan's usually scattered R&D on energy-related S&T model, estimating that 30.3 billion TWD to finance R&D will be invested within five. In 2010 alone it is predicted that 4.6 billion TWD will be spent. In August 2008 this plan had already being announced publicly but looking for an appropriate proposal, the three main aims are to improve energy self sustainability and security, reduce greenhouse gas emissions and develop innovation in the energy industry. While the main direction of this plan is focussed on four key areas: 'energy S&T strategy', 'energy technology', 'saving energy, reducing CO_2 and 'fostering of talent'.

In relation to renewable energy technology, this plan is concerned with technology involved in solar thermal energy, solar power, wind power, biomass energy, geothermal and ocean energy. Particularly worthy of attention is the fact that this plan takes the three main targets mentioned above and proposes the short to mid-term potential of renewable energy development. Of these offshore large scale wind power generators, ocean energy (ocean current generated energy) and geothermal energy (natural gases hydrate) all possess self-sustainability potential and from a long term perspective, have the greatest potential in increasing renewable energy generated power as a total percentage of installed capacity. While in terms of reducing greenhouse gas emissions, wind power, solar power and biomass energy are all limited by Taiwan's limited resources, and therefore their contribution too is limited. Therefore this plan highlights a number of more effective methods including nuclear power, hydrogen power, fuel cells and ocean current generation.

As for the energy industry itself, since Taiwan's energy industry is export led, with small medium sized wind power generator systems, solar cells, organic solar cells and biomass related industries, and requires the government to invest significantly, this plan suggests that in the short term, even in the mid-term development in the energy industry should be expected. Along with energy policy stakeholders, this plan's S&T strategy group is responsible for drafting legislation and formulating other economic incentive policies, for example: energy prices, tax levels, land tax remittances and advantageous loans amongst others. The Ministry of Economic Affairs Technology Bureau is responsible for industrial (research loans) and Special Technological Projects, in terms of industry R&D. Over the years successive increases in energy R&D spending has increased coordination of various model plans and strengthened cooperation between industry and academics in research. In short, Taiwan currently in terms of R&D planning, in the short term is still focussed on solar power, biomass energy and wind power generators. In the long term however marine current power possesses greater potential for providing the majority of renewable energy. At present R&D is still focussed more on cost estimations and resource analysis.

6.2.1. Solar power

In comparison to other new energy fields, in terms of solar power production, manufacturing facilities and related technological R&D, Taiwan is at the same pace as others in the international community however future potential for innovative technological breakthroughs still lags behind that of more advanced countries. However there still remains a possibility for leading breakthrough in some aspects of this field. The field that Taiwan has most actively invested in, which internationally is also one of three innovative new directions [32], first is organic solar cells, which belongs to the innovative R&D field of the panelling industry, however the cost of R&D is high, the basic scientific density large, and in relation to R&D, Taiwan still has this dilemma [33]; second, is nanotechnology used in PV research, although Taiwan has experience in researching various nanotechnology fields, however the EU's use of PV technology, especially in improving converting efficiency, enables them to lead the way in this field; finally, in terms of CPV concentrating, in terms of technological R&D into automatic controls, Taiwan is far from weak, however the challenge of how to integrate solar energy cells into a full scale R&D project to take the lead in CPV technology is the key question which Taiwan must consider [34].

Taiwan's main plans for research in these fields include: spending 140 million TWD in resources on R&D into the next generation of solar power cells and system integration application

plan; 90 million TWD on metallurgical polycrystalline silicon and new model solar cell three year plan, four plans all within the scope of 34 million.

6.2.2. Wind power

Taiwan's wind power plans are mainly developing blueprints and directions. From 2006 to 2009, this plan was based on three main aims: exploring the potential of developing offshore, MW wind power turbines industrial facilities, developing key component and the application of the whole.

(1) Offshore wind development plan: due to a limited number of sites to develop Taiwan's on land wind power turbine installations, therefore offshore wind power turbines must be developed. However the process of attempting to construct an even larger site on the ocean bed, collecting power and delivering it back to the mainland, all increase the cost of offshore wind power development [34]; and these are all factors that Taiwan needs to consider as it develops the potential of offshore wind power turbines. An Industrial Technology and Research Institute report pointed out that up until 2010 Taiwan has still not possessed the ability to self manufacture key components needed to develop offshore wind power [35], therefore an increase in the 'self-manufactured ratio' of wind power turbines is one of Taiwan's most pressing R&D subjects.

(2) 'MW wind power turbine industry facilities development plan', hopes that greater integration of the mechanisms, electrical engineering expertise and materials which form the technological basis, will enable the key components for wind energy to be established with an integrated core in order to improve Taiwan's technological self sustainability. Offshore wind power turbines can already generate 3.6 MW and in the future they will design wind power turbines to reach an installed capacity of 5 MW. It is also hoped that in future years a standard system for wind power related technology will be set [34], becoming a key to R&D.

(3) According to the Taiwan Wind Power Key Component Development Plan, Taiwan has the potential to break into the market through manufacturing three main target key components: (1) developing highly reliable step-up gear box; (2) 2 MW high effective wind blade technology; (3) blade pitch and power steering.

In addition, the 'Exploration of Wind Power Generator Environment Construction Plan', includes implementing an assessment on the feasibility of Taiwan's offshore wind power generator research plan and executing R&D planning, Penghu Huxi wind power generator plan provides approximately 100 million TWD for drilling to explore the ocean geology.

6.2.3. Biomass energy

The current scale of Taiwan's biomass plan is relatively broad, in terms of heat and power systems, besides combining the Environmental Protection Department's garbage incinerator and methane use biomass energy generated power application, along with the step of bio-fermentation of organic waste with the potential to produce 100,000 kw of heat and power, the current biomass energy transforming technology which have already been developed include the solid refuse derived fuel (RDF-5), cracking and liquefying along with gasification, pyrolysis, ligno-cellulose and water splitting technologies [36] (OECD/IEA, 2009).

Taiwan's solid refuse derived fuel (RDF-5) technology has already been developed to maturity. The first domestically constructed urban waste solid refuse derived fuel factory is now in use in Hualien County Fengbin village (with a handling capacity of 1 ton per hour, RDF-5 calorific value of 4000 kcal/kg, humidity ratio of less than 10%), and this technology has already been transferred to industrial applications, to establish a total production capacity of 420 ton per day business refuse RDF-5 production line (the Ministry of Economic Affairs Energy Bureau 2007). Future technological development items include decreasing the set up cost, increasing production capacity, developing low energy consumption manufacturing procedure, developing centrifugal and high temperature corroding technology, increasing average operating efficiency for electricity plant and so on.

Beginning in 2006 besides encouraging Taiwan Sugar Corporation and other businesses to invest in factory facilities, to use sugar (sugar cane) and starch (sweet corn or sweet potato) as primary materials to produce and manufacture bio-ethanol, nuclear energy research is currently invested in transforming cellulose into ethanol as a forward looking production technological R&D (Xie Zhiqiang, 2007) [37].

Current large scale plans and projects on biomass energy being carried out in Taiwan include, spending 110 million TWD on biofuel technology development and promoting plan along with 10 million TWD for developing key technology for transforming cellulose into ethanol, in the future.

6.2.4. Geothermal and ocean power

In accordance with Taiwan's key energy technology R&D motivations and strategy (Energy Bureau 2007) and the outcome of the first stage assessment of Taiwan geothermal resources, Taiwan has more than one hundred sites possessing signs of hot springs with geothermal properties. However of those only 26 sites have the potential to develop into geothermal, with a rich million thousand kilowatt store of potential power generating capacity. The Industrial Technology and Research Institute and Taiwan Power Company are also currently setting up geothermal power generating installations, but this power is still not in operation. Taiwan's geothermal power generating technology development and multiple target use promotional plan was released in 2008 with a combined budget of 120 million TWD.

Again in accordance with Taiwan's key energy technology R&D motivations and strategy (Energy Bureau 2007), marine energy is mainly distinguished into five main forms including tidal energy, wave power, marine current energy, marine thermal energy and natural gas hydrate. A survey of the tidal differences in the sea surrounding Taiwan showed that there was no room to develop tidal energy. A key survey exploring potential sites for natural gas hydrate showed that in the early stages of exploring Taiwan's Southeast Sea 3.0 billion cubic meters of Nature Gas Hydrate was found. Although 500 billion cubic meters of methane were discovered, relatively speaking enough potential generated power to sustain Taiwan for fifty years, however the problem lays in the fact that methane contributes to the greenhouse effect. Wave power, marine current energy and marine thermal energy have all been developed to a small extent and their related technologies too have also been developed in part. Wave power has not yet reached the assessment stage (Hong Zhang Chun, 2008) while marine thermal energy and marine current energy have already entered the planning stage, however the current plans are all relatively small in size (Lao Zhengyi, 2008), Of all these different potential ocean energies, the one with the greatest potential currently is the Kuroshio generation based in the sea off of Taiwan's East Coast (Hu Sicong, 2009). Recently the Kuroshio generation team from Taiwan University during a presentation at the Executive Yuan S&T meeting pointed out that: 'black tide' (KUROSHIO) generated power is possibly the most hopeful of all renewable energy development directions. Its advantages are that CO_2 emissions are reduced to nearly 0; ocean water can be transported at a speed of 20 million square meters per second. Estimates suggest that it

Table 2
2008 Research Plans on Taiwan's Energy S&T.

2008	Number	Spending	Unit: New Taiwan Dollars			
			Average spending per project	% of Total research spending	% of Total energy research spending	
Total for national research	25012	60563115	2421	100%		
Science & technology	18531	52082614	2811	86.00%		
Energy related research	911	8219129	9022	13.57%	100.00%	
Renewable energy	566	8057801	14236	13.30%	98.04%	100.00%
Biomass energy	141	3153351	22364	5.21%	38.37%	39.13%
Wind energy	90	387444	4305	0.64%	4.71%	4.81%
Solar energy	322	4310853	13388	7.12%	52.45%	53.50%
Geothermal	9	165679	18409	0.27%	2.02%	2.06%
Ocean energy	4	40474	10119	0.07%	0.49%	0.50%
Other	345	161328	468	0.27%	1.96%	2.00%

Data source: GRB Resource database [40]; author's construct. Renewable Energy here refers to Biomass, Solar, Wind, Geothermal and Ocean energy not including traditional water power.

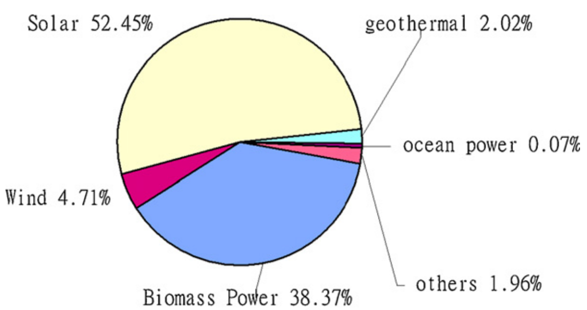


Fig. 6. 2008 Percentage of overall spending invested in various energy R&D.*Data source*: GRB Resource Database [38]; the author's construct.

possesses 6.0 billion kilowatt of installed capacity. Successful development of this new energy source would have the potential to contribute considerably to Taiwan's electricity supply and improve the proportion of energy coming from renewable energy sources. The challenge of power generating technology is in how to develop a water current turbine which can be used under water on the ocean bed. However the problem is that when Taiwan harnesses the power of the black tide there is the potential that it could change the characteristic of marine currents and influence both the Northeast Asian and global climate, therefore operationally, cautious controls needs to be put in place (Wang Meng Ping, 2008).

Comprehensive Plans: Ocean energy generated power system and testing expenses 30 million TWD, added to this the natural gases hydrate survey plan at 22 million TWD, along with other related plans the government's investment in this subject surpasses 100 million TWD.

6.3. R&D distribution analysis

Of Taiwan's 2008 National research spending of 60.5 billion TWD, 52 billion TWD of it was allocated to S&T research[8], that is to say S&T research accounted for 86% of all research spending in 2008. Of this 52 billion TWD, 8.2 billion TWD went on energy related R&D[9], so energy related research occupied 13.57% of all government spending on research (Table 2). Of all spending on energy related research, the amount spent on renewable energy accounted for 98%, and of this solar energy R&D accounted for 52%. However, surveys found that Taiwan's solar energy generated installation capacity only accounts for 0.01% of all domestic installation capacity, in fact the generated power from solar energy is not even as much as 0.01% of the total generated amount and in light of the amount being invested into this field this should be strengthened. In fact from 2008 Taiwan was ranked as fourth largest solar energy producer in the world, with a production level and production value of 1080 MW and 2.6 billion U.S, respectively, thus this research and production application in the main is for foreign markets. While nearly 8 billion TWD a year has been invested into the photovoltaic market, the total spending on R&D into wind power is only 380 million, occupying 4.71% of the total spending on energy research and only 0.25% of total generated power. Of all energy S&T research, biomass energy makes up 38%, second to solar powers 52.45%, there were only 13 items of research being carried out into geothermal and ocean energy with an overall investment of 200 million TWD, which accounts for 2.5% of overall spending on energy related R&D (Fig. 6).

In conclusion, Taiwan's renewable energy research accounts for 13.30% of all national research with solar energy and biomass energy in first and second place, respectively.[10] In terms of Taiwan's natural environment, solar energy development has more limitations, biomass energy too is limited to agricultural planning; large scale energy operations are also limited. Despite the fact that after consideration of Taiwan's island climate and terrain, geothermal and ocean energy are considered to be the renewable energy forms which possess the greatest potential for future development, only 0.34% of the total national S&T research spending was channelled to these areas. Geothermal research accounted for 2% of all energy related research and in 2008 the installed capacity of its generated power reached 131.8 thousand watts, yet it hasn't until now contributed anything in real terms to the national power generating grid. Thus Taiwan's energy research is still motivated by considerations of economic interests more than with adjusting national energy structure to improve Taiwan's energy supply structural needs. Therefore there needs to be more effort made in developing new energies which are most appropriate to our countries domestic demands (Table 3), and through this the opportunity to improve Taiwan's high level of dependency on imported energy and reduce the country's high CO_2 emissions.

8 'Science and Technology' GRB Resource Database Category Search excluding humanity social and art categories and agricultural categories of transport, advertising and economic related items [38].

9 'Energy related research' GRB Resource Database Keyword consultant, including humanity, social and art category along with agricultural category, agriculture, transportation and sale, Marketing, economy related article [38].

10 Energy research high level of correlation, therefore items are not exclusive but rather are interrelated therefore the total amount of these items added together surpasses100%, and this part is where there is an overlap in the research.

Table 3
2008 Taiwan renewable energy related large scale research plans.

Program field	Program	Expenditure (million TWD)
Comprehensive	Development and Application of New Energy Technology	200
Solar	Next Generation Solar Cells and Integrated Photovoltaic System Research Project	140
Solar	MW High Concentration Photovoltaic Demostration Project	130
Solar	MG-Poly Silicon Materials and New Solar Battery Programe	90
Solar	Photovoltaic Technology R&D and System Dissimination Project	40
Wind	The Project for Establishing the Development Infrastructure of Wind Energy, In-Site Investigation on Tide, Current, Wave and Sediment for Project of Wind Power Generators at Hu-Si, Peng-Hu, In-Site Investigation on Tide, Current, Wave and Sediment for Project of Wind Power Generators Assessment in Taiwan, Development of a Multi-Mode and Energy Saving MPPT Chip for Wind-Photovoltaic Energy Conversion Systems and Chip Designing and System Implementing of Power Converters for a Grid-Connected Solar Photovoltaic and Wind-Turbine Hybrid Generation System	100
Biomass	Development & Dissemination of Bio-fuel Technologies	110
Biomass	Investigation on Key-Technology of Transformation Cellulose to Bio-alcohol	100
Biomass	The Evaluation of Non-Crop Feedstock Pretreatment Technologies in Biorefinery	16
Geothermal	Technology Development and Multi-Purposed Utilization Promotion of Geothermal Power Energy, Investigation and Evaluation of Gas Hydrate Resource Potential in the Offshore Area of Southwestern Taiwan: Seismic and Heat Flow Studies. . .etc.	120
Ocean power	Evaluation and Testing of Ocean Energy Conversion, Potential Gas Hydrates Resources in the Offshore Area of Southwestern Taiwan:Biogeochemical Investigations	100
Comprehensive	ITRI Innovation & Advances Technology Research Program	1900

Data source: GRB Resource database [38]; author's construct.

7. Taiwan renewable energy related legal construction

7.1. Energy Tax Act Draft

In recent years, as a result of inflation of oil prices and growing calls for the rationalization of oil prices, in August 2006 Taiwan's Ministry of Finance started to draft the 'Statute on Energy Tax Draft', with the hope of making appropriate adjustments to the price of energy, this plan included taxation on a number of energy products including: gasoline, diesel, aviation fuel, fuel oil, coal and natural gas. According to the most recent Executive Yuan version from October 2009, Taiwan's will adopt a new ad valorem tax levying method, making adjustments to various tax levels once every 10 years. Following this new law coming into effect the original petroleum and gas commodity tax and diesel oil fuel prices will all be cancelled [39].

However, if considered from the perspective of environmental sustainability, the effectiveness of Taiwan's plan to levy taxes on various forms of energy to achieve the goal of promoting energy savings and the reduction of CO_2 emission levels is insufficient when compared with the more direct benefits of carbon tax levying. Carbon taxes are levied in accordance with the CO_2 emissions of each individual energy product and CO_2 emission levels enable a more directly controlled result to be achieved, whereas energy tax needs to be adjusted moderately before achieving the optimum tariff rate. Therefore, the levying of energy tax should incorporate CO_2 emission considerations, in order to truly reflect the outer cost of energy products; however, such CO_2 tax tools have yet to be incorporated into the current 'Greenhouse Gas Reduction Act'. No matter whether energy tax or CO_2 tax are being levied, domestic economists emphasize the need for coordination with centrally controlled policy in terms of administration or in addition to adopting a CO_2 exchange system, in order to achieve real results. The response capacity of small and mid-sized domestic enterprises' is also an important factor for consideration, as it would be inappropriate to use the same tax policy on them as with large scale enterprises.

7.2. Greenhouse gas reduction act draft

Beginning in 2006, the Environmental Protection Department formulated the 'Greenhouse Gas Reduction Act' draft. Currently this law has already reached 6 chapters with altogether 28 articles, the content include three main sections: 'Government rights and responsibilities', 'CO_2 Reduction Strategy Policy' and 'Education Propagation'. According to the regulations of this draft, the first stage for reducing greenhouse gas emissions is to establish emission validation, register and verification procedure. By actively reducing levels of emission, reporting and registering as well as implementing subsidies and incentives to pressurize at the source of emission, it is possible to reduce the levels of emissions even below that set by central controls. Moreover, we wait in expectation for formal administrating standards for CO_2 reduction levels, recovery stage implementation of effective standard systems, CO_2 trade, central controls and other response policies. But when reduction targets remain unmet, the government must reconsider engaging to implement CO_2 taxation system.

Once this statute has been passed, it is predicted that the statute will cause conflict with domestic high energy intensive industries. While Renewable energy industries and domestic demand markets are expected to gain greater expanded development space. However, currently speaking the main opposition can be heard from the wave of voices arising from the Ministry of Economic Affairs and Industrial fields. In terms of reduction targets, the most recent greenhouse gas reduction targets to be set are stated in the summary to the 2009 National Energy Conference: between 2016 and 2020 return to the CO_2 emission rates from 2008; by 2025 return to Taiwan's 2000 emission rate. These reduction targets show Taiwan as remaining a significant distance behind that of more advanced countries. According to Article 6 Item 2 of the draft: 'Central Industry Competent Authority should in accordance with the previous two schemes set greenhouse gas reduction action plan along with reduction targets, every three years examine and revise'. Taiwan should at the appropriate time examine the reduction targets stated above. Moreover these targets cannot be reduced in order to cross the threshold, causing the administering of policy to fall into an illusion. When faced with the high energy intensive domestic industry structure and the energy saving and CO_2 targets proposed by the new government, this legal power must increase the pace of the legislation process. This law can be seen as being position above both the 'Renewable Energy Development Act' and 'Energy Tax Law' and must work in coordination with these in order to produce a truly effective result. The promotion of domestic renewable energy can also provide realistic development targets in order to improve Taiwan's energy; ensuring energy security and taking renewable energy industry another step in its development.

7.3. Energy management law revision

Taiwan's first step in strengthening its energy management was in 1980 when the 'Energy Management Law' aimed at promoting more effective use of energy was passed. In recent years due to the government's own focus on energy saving and CO_2 reductions, in 2005 National Energy Conference there were calls for revisions to be made to this law. The main demand in this was to appeal for tests and checks to be made on the conditions and standard products used by large scale energy intensive consumers and complete energy efficiency obligations. For this purpose, revisions to the 'Energy Management Law' were passed in June 2009 by the National Congress, the main revision content included: (1) The Central Committee Ministry of Economic Affairs should formulate a Framework of Energy Development with assessment standards, using assessment standards to carry out advanced test and check procedures on large scale energy intensive consumers to implement a preventative stage of management; (2) Domestic manufactured or imported energy facilities, equipment, vehicles and other products should be required to include a sign to indicate the energy intensity and efficiency of the product, providing the customer with full information;(3) designate energy user energy use efficiency, these levels should correspond to the energy saving regulations formulated by the Central Committee.

Other revision points made in 2009 were related to the improvement of penalties, appointment of energy management and abolishment of regulations referring to energy storage equipment. For renewable energy stakeholders, besides the source of R&D spending (energy R&D fund), this law also aims at energy use and management aspects, and in terms of energy facilities, regulates that users and large scale investors must declare and gain recognition from the Central Committee; through this mechanism the government can suppress petrifaction, steel and electricity industries' new plans or enlargement, and reversely can enable the market for renewable energy to enlarge, speeding up the development of renewable energy technological service industries and indirectly driving the first stage of renewable energy technology service personnel to conform to trend which has emerged in recent years of an increasingly service orientated renewable energy industries.

In terms of the appropriate order of these laws, the regulations set out in the 'Energy Management Law', 'Electricity Industry Law' and the 'Renewable Energy Development Act' all impact on renewable energy stakeholders; the 'Renewable Energy Development Act' should be seen as dealing with the special legal position of renewable energy, whereas power generating facilities are not regulated through this law, it is therefore more appropriate to use the 'Electricity Industry Law' to regulate this area. When neither of these laws are appropriate, one would finally use the 'Energy Management Law' to regulate. In conclusion, although as a preventative, holistic examination method for surveying large energy users this law is applicable, however in reality these targets will not be met until the day that the government announces related standards and energy saving laws. In particular regulations targeted at establishing systems for ensuring energy efficiency in the manufacturing industry, energy standards, green architecture standards and energy intensive standards for products, should make reference to the standards used in the EU and other advanced countries, combining renewable energy technology and application.

8. Taiwan renewable energy policy: defects and recommended directions for improvements

At the end of 2009 the Kyoto Treaty will expire; following the adoption of a new treaty, concerned with global climate change, which will be signed in Copenhagen, the whole world is about to enter the Post-Kyoto Protocol generation. Taiwan should move into this new generation by reformulating its various targets in relation to renewable energy installation capacity. According to targets set at the 'Industrial S&T Strategy Meeting' held by the Executive Yuan held in 2007 (targets which were not incorporated into the formal summary at the 2009 Energy Conference) it was predicted that in 2015 the power generated from renewable energy sources should have a total installed capacity of 4.972 GW, and account for 11.2% of Taiwan's total generated power capacity. By 2025 it was predicted that the total generated power from renewable energy will have reached 8.45 GW or 14.9% of total power capacity. Various renewable energy development targets were also set at this meeting. At the same time, during the promotion in 2008 for the government's 'Green New Government' scheme, the Executive Yuan promised to increase government investment in 'green' public construction projects by 10% as a standard, 'Promoting Economic Expansion Public Construction Investment Plan' as a direct strategy for promoting renewable energy industry development. However both these targets and the current government push for renewable energy development have room for examination and improvement.

8.1. The unsolved case of the renewable energy power price debate

According to Article 6 of the 'Renewable Energy Development Act', it states that the 'Electricity Pricing Committee' should be established to determine feed-in tariffs. In terms of renewable energy wholesale feed-in tariffs, Taiwan has already held a public hearing on fees, to listen to the opinions of those from various different backgrounds and fields, and on the 3rd October 2009 the Energy Bureau announced a list of the committee members, including: the Industrial Development Bureau, Ministry of Economic Affairs, the Bureau of Energy along with other government ministries; the Consumers' Foundation, Chinese National Federation of Industries and a group of academic experts. However, according to current announcements on the feed-in pricing system for power generated from various renewable energy sources, photovoltaic generated power is set at 7 TWD a kilowatt; wind power at 2.18 TWD a kilowatt; hydropower and biomass energy at 2.096 TWD a kilowatt. Although the Ministry of Economic Affairs Energy Bureau announced that the average cost of fossil fuel generated power as 2.0961 TWD per kilowatt, but in 2008 Taiwan's the cost of power generated by fossil fuel was actually 2.76 TWD per kilowatt, and if this is compared with the power prices above it is clearly higher than the current feed-in prices announced by the government. From the current situation it is clear that the temporary prices in place violate the 'Renewable Energy Development Act' and its regulation that the prices of renewable energy 'should not be lower than that of the average price of domestic electricity industry's fossil fuel'. Therefore, a survey of the tax year adopted by the committee is urgently necessary.

If following the negotiations on altering electricity prices, the prices while rising, still fail to reach the average cost stated above, it will mean that renewable energy will still lack the economic incentive necessary to encourage industry and public investment, and for this reason greater coordination and communication between the Power Price Committee and social groups is vital. The calculation formula and references for the feed in tariffs do not take into account the amount of intensive natural disasters occurring in Taiwan or in light of such occurrences properly consider the proportional effect. Moreover, if the decision is made to adopt lower pricing fees for renewable energy, then subsidies reversely should be increased and the user conditions for various financing instruments should be broadened for the sake of public consumers, in order to stimulate industry and consumer inclination to install.

Table 4
2008 Taiwan Three Large Industries' GDP.

GDP of three large industries	Total	Unit: 1 million TWD		
		Agriculture sector	Industry sector	Service sector
Total	12340923	208258	3090316	9042349
Percentage	100.00 (%)	1.69	25.04	73.27

Data source: DGBAS [40].

8.2. Incomplete construction of Renewable Energy Law and Regulations

In terms of the current 'Three Energy Laws', while the 'Renewable Energy Development Act' and 'Energy Management Law' have both completed the legislation process having been both passed and revised, both the 'Greenhouse Gas Reduction Act', 'Energy Tax Act' and the 'Sustainable Energy Basic Law' are all waiting to be passed to the Legislative Yuan and are currently being locked in a seesaw struggle between the government, environmental groups and high energy intensive industries. The reality is that if government energy policy contained a legal basis, it would be compelled to strengthen controls and economic incentives in order to achieve overall national energy targets. Renewable energy development is the same, while having already passed the main law on renewable energy 'Renewable Energy Development Act' however this law and related set of laws are still far from complete. Even this main law in terms of definition of power prices, renewable energy thermal use, renewable energy development fund, research development and parallel connection of obligations, still have many areas in need of revision, while the prioritization of various items remains without a clear standard.

Regulations on economic incentives such as power prices and feed-in tariffs, installation subsidies, exploration subsidies, research subsidies and financing instruments have still not been improved; energy tax, greenhouse gas emission, energy efficiency, environmental protection, the land, agriculture and forests, the electricity industry and oil laws should all be revised and coordinated together, in order that they should successfully develop domestic renewable energy industry and increase the public's interest in installing renewable energy systems. Finally, part of the article about housing tax credit in the 'Statute for Upgrading Industries' will expire at the end of 2009 and the new housing tax credit scheme is at present still awaiting examination by the Legislative Yuan. This important policy tool should be oriented towards a trend of improving the R&D capacity of businesses, encouraging government R&D into renewable energy technology and has the potential to offset the problem produced by renewable energy R&D of national unfair allocation of resources.

8.3. Overall incomplete industry structure

At the 2009 National Energy Conference the consensus in relation to adjustments to industry structure was that 'new large scale investments should prioritize green energy industries and non energy intensive industries', however, this conference did not formalize this anti-expansion of fossil fuel industry policy commitment, at the same time they also did not incorporate the suggestion of environmental groups for monitoring of energy intensive industry investments.[11] Surveying Taiwan's 2006 and 2007 fossil fuel industry energy concentration, which increased 1.21% and 11.47%, respectively, in relation to the energy concentration of the whole of Taiwan which decreased 2.31% and 0.86, respectively, it is clear that policies supporting the expansion of fossil fuel industries are violating society as a whole's non-energy intensive target.

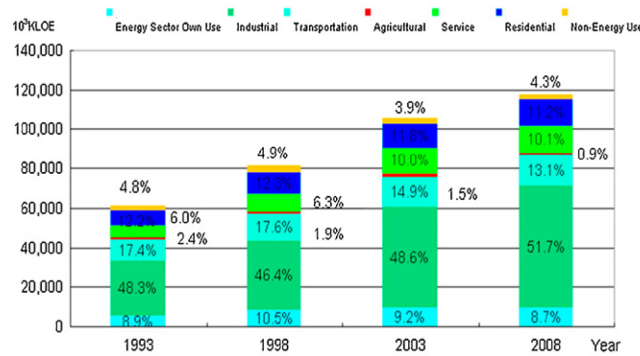


Fig. 7. Structure of total domestic energy consumption (by sector).*Data source*: MEA [1].

At the same time, from an analysis of Taiwan's current industry structures, according to Directorate-General of Budget, Accounting and Statistics [38], in 2008 Taiwan's service sector accounted for 73.27% of the national GDP, while the industry sector only accounted for 25.04% and the agriculture sector only 1.69% (Table 4). However, from Fig. 7, it is clear to observe that although the industry sector only accounts for a quarter of the GDP, it is however highly energy intensive, accounting for more than 50% of all energy consumption. The difference between the two clearly shows that Taiwan needs to implement a large scale industry survey, in order to construct a more balanced industry structure. Not to mention that when faced with the requirements set by international climate change treaties, the industry sectors where CO_2 emissions are relatively high can pass their excess on to less energy intensive industries. In reality those industries which have 'high energy concentration, low economical advantage' are clearly in need of adjustment and the government needs to implement appropriate measures to adjust the industry structure and influence the policy direction in relation to green science and technology R&D and industry strategy and overall expand renewable energy.

8.4. Overall greenhouse gas reduction targets without prospects

The main aim of developing renewable energy is to reduce CO_2 emission levels and stabilize energy security, thus the close correlation between greenhouse gas reduction targets and renewable energy development. Since greenhouse gas reduction levels were set in the 'Sustainable Energy Policy Principles' in 2008, and the related reduction targets adopted were reaffirmed again at the 2009 Energy Conference. However in comparison with international standards, the government's attitude to reduction levels is clearly conservative. In fact, achieving reduction targets and adjusting the industry structure are in urgent need of implemen-

[11] Environmental groups suggested that, 'Until the environmental assessment is passed should not carry out examination of energy intensive industries investment plan', however the 2009 National Energy Conference Official Summary showed that the Taiwan government's promise to prioritize green industries when investing were merely symbolic, energy intensive industries, during the examination process, can still barge passed those greener industries.

tation, the government should not take one thing into consideration to the neglect of another and in the process fail to make the most of development opportunities for sustainable energy. No matter in terms of the international energy summit to be held in Copenhagen in December 2009 or the regulations on developing nations, they are all at conflict with Taiwan's economic productivity. Most serious of all is the possible trade embargo or forfeiting of CO_2 trade advantageous position in particular, to say nothing of the fact that Taiwan's GDP per capita and CO_2 emission level have both been on an upward trend much higher than the majority of countries.

In conclusion, currently Taiwan's drive to reduce greenhouse gases is still stuck in the preparation stage for examining and announcing targets, while the author predicts that the implementation of CO_2 emission trade and overall control stage will still be a few years in the coming before these policies can be practically implemented. Taiwan has still not joined the international authentication mechanism. The government should quickly complete the process of setting appropriate reduction targets and incorporate these targets into the regulation contents of the 'Greenhouse Gas Reduction Act', rather than government degrees simply propagating slogans. Only when this happens can the social benefits of renewable energy fully be brought into play.

8.5. The effect of Nuclear power being 'edged out'

According to the summary from the 2009 Energy Conference, the government has still not positively confirmed that they have 'rejected nuclear power as a form of low CO_2 energy'; instead there was an appeal to 'strengthen nuclear power safety'. However nuclear generated power in Taiwan has for a long been a source of controversial debate. If environmentally sustainable energy such as renewable energies are rejected by the general public in the way that nuclear power has been, then no matter the budget allocation or installation portfolio, the potential development of renewable energy will be seriously limited. The cost of constructing one nuclear power station in Taiwan is approximately 200 billion TWD (4th nuclear power plant), if Taiwan wants to develop its renewable energy to reach the targets set by the government, the government must first reduce and limit the length and breadth of current nuclear power development and related benchmarks. In the past academics have often proposed that the extent of power generated by nuclear energy made this form of energy irreplaceable, now however, with the gradually decreasing cost of renewable energy this argument has been weakened.

Despite the environmental legitimacy issues related to nuclear power, in practical terms the government has already invested the spending needed to extend the nuclear power program domestically into the 'Energy Saving CO_2 Reduction Plan', showing that currently Taiwan still actively recognizes nuclear power as one method of decreasing CO_2 emissions. In contrast to the German approach, which has taken gradual steps to discard nuclear power and actively developed renewable energy source, with a plan to have closed all nuclear power plants by 2021, Taiwan remains relatively friendly to nuclear power. Despite the fact that in the short term developing nuclear power has brought a reduction in the level of CO_2 emissions while in the progress of developing renewable energy CO_2 emission has not yet seen any dramatic change; however, in the long term the problems of handling nuclear waste grows day by day. Surface costs are unavoidable and national spending along with the cost of developing will continue to increase, and the investments made into the nuclear industry will take away from that of renewable energy leaving the latter sidelined.

9. Conclusion

In order to protect Taiwan's energy security as well as ensure environmentally sustainable development, as well as promoting continued economic grow despite the industrial transformation which the approaching 'Post Kyoto Treaty' generation, can be expected to bring, then the government's various ways of promoting renewable energy already demand immediate attention.

At present renewable energy faces many social, economical and systematic problems in Taiwan, reflected in the current legal construction and in terms of harmonizing cooperation between different government policies, there remains considerable room for improvement, including: (1) increase speed of 'Energy Tax Law', 'Greenhouse Gas Reduction Act' and other legislative work, to bring into play the full coercive function of government policy; (2) promote the rationalization of energy prices to reflect true external cost and through levying energy or CO_2 tax to help promote renewable energy generator installation industry as well as amongst the general public, to reduce the social problems of inflated energy prices; (3) carefully assess the necessity for investment and construction of each energy intensive and nuclear energy power plant, to avoid financial overprotection of the fossil fuel industry and related electricity industry; benchmarks should foster green industries, to reduce the effect of other energy development being sidelined by a lack of investment and incentives, to increase the overall percentage of all power which comes from renewable energy sources; (4) introduce U.S. Net-Metering system, having decreased the prices of traditional power, taking the excess electricity and selling it to electricity companies, to increase efforts to stimulate greater interest in normal customer installations; (5) the purpose of the renewable energy development fund should be clearly designated for the purpose of technological R&D, separately formulating short, mid and long term renewable energy technological R&D plans with development potential and incentives; (6) the government should increase the speed of establishing a complete renewable energy industry chain structure, pioneering a domestic renewable energy service market and continue implementing green energy installation investment; manufacturing and importing tax credit regulations; (7) the government should continue to use policy tools to promote public large scale installation of renewable energy systems, and establish rational public energy prices.

Taiwan's current industries and energy use structure are ripe for transformation; the question now is how to provide policy incentives and coordinate both internationally and domestically to formulate laws and regulations, actively implementing technological R&D as well as adjusting the industry structure to open up opportunities to develop renewable energy, equally important at the same time is to protect Taiwan's future energy security and socio-economic sustainable development.

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